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CALIFORNIA COAST NEARSHORE PROCESSES STUDY
ERTS-A EXPERIMENT #088

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16. Abstract:

This Type II progress report contains the techniques used for enhancing and analyzing nearshore processes from ERTS-A and aircraft data. Four California nearshore sites are used as test cells including the San Francisco area, Monterey Bay, Santa Barbara Channel and the Los Angeles area. Techniques used for analyzing the test cells included direct photographic processing, computer compatible tape gain change enhancement, discrete point density analysis and plotting and densitometer enhancement. Using these methods, it is possible to measure the seaward extent of the suspended sediment transport and to differentiate sediment levels within the individual sediment lobes. The movement of riverine discharged suspensates and coastal sediments by currents was an intricate part of the sediment transport analysis. The larger estuaries in the test cell areas were also studied for flushing characteristics.

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PREFACE

Multiple elements under the broad topic of nearshore processes are being studied with spaceborne sensor data supplemented by aircraft and seatruth information. Four California coast nearshore sites are used as test cells, including the San Francisco area, Monterey Bay, Santa Barbara Channel and the Los Angeles area. The principal elements being investigated are nearshore currents, seasonal river discharge, sediment transport and estuarine flushing. Several data processing procedures are being successfully used to obtain information from the collected data. Photographic processing, discrete point density analysis of ERTS computer compatible tapes, isodensity plotting and aircraft collected magnetic tape playback enhancement are the primary processing techniques. To date, it has been possible to measure the seaward extent of the suspended sediment transport and to differentiate sediment levels within the individual sediment lobes. The study of the transport of riverine discharges suspensates and coastal sediments by nearshore currents was found to be readily possible utilizing the available data. The transitory seasonal nature of the features being measured and the common weather problems encountered in the California coastal area make continuing repetitive data coverage necessary for this study.

The coast of California continually demonstrates to the coastal engineer and scientist the great need for information about the processes of nature that constantly attack the land. This is especially true in a number of sections along the California test areas. Many beaches, roads and shore protection structures have failed because their designers either had insufficient data concerning the natural laws involved or did not heed the warnings of nature's forces. What is required for intelligent planning is a bank of both historical and current data concerning the nearshore environment. The synoptic repetitive view afforded by the ERTS imagery is starting to produce a data base for this type of information.

The ERTS film and computer compatible tapes received to date have contained information in most cases which can be used in analyzing the study objectives. During the fall months of 1972 lack of suspended sediment in the coastal waters was a problem to this study. The sediment acts as a tracer which can be detected on the ERTS imagery. Heavy rains along the California coast during January and February have now eliminated that problem.

One simultaneous contract flight and two supplementary aircraft and helicopter data collection flights have taken place to date. Three more flights are planned for the next reporting period. The CCT discrete point density analysis which has been used for measuring water radiance along lines on ERTS imagery has now been expanded to provide contour density information. Special photographic processing techniques have been utilized to enhance the boundaries of the nearshore sediment so the sediment transport, currents and river discharge could be studied. Similarly, densitometer traces and isodensity plots have been made which result in detailed enhancement of the nearshore processes. Comparison of these methods for ERTS channels 4 and 5 and simultaneously collected aircraft and seatruth data has provided not only surface sediment distribution but water penetration information.

Using the above mentioned techniques, the effect of the California and Anacapa currents have been traced in the Santa Barbara Channel. Suspended sediment from river discharge and coastal erosion in the area have been mapped to a distance of 40 miles offshore. Detailed differences in the nearshore suspended sediment content have been measured. In the San Francisco test cell, suspended sediment and surface currents have been detected and delineated. The ability to differentiate morphologic units in the nearshore area was demonstrated. Minor depositional features at the Newport Harbor entrance were detected and measured on the ERTS imagery and confirmed on aircraft data. The detection of suspended sediment and its associated dynamics has been clearly demonstrated. It is now necessary to make seasonal comparisons of the nearshore processes and to continue the development of the techniques for extracting information from the available imagery.

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1. INTRODUCTION

The California Coast Nearshore Processes are being studied utilizing spaceborne sensor data, aircraft data and sea truth information. The major elements to be investigated include nearshore currents, nearshore sediment discharge, seasonal river discharge and estuarine flushing. Study test cells are: San Francisco area, Monterey Bay, Santa Barbara Channel and Los Angeles area. One simultaneous contract aircraft flight and two supplementary aircraft and helicopter flights have taken place to date. Processing techniques for analyzing nearshore processes include densitometer plotting, digital computer mapping of areal seawater density distribution, spectral channel comparison and photographic enlargement and gray tone variation.

The quality and coverage of the ERTS-A data record, to date, indicates the fulfillment of the major study objectives will be readily possible. Furthermore, the results, to date, are showing the transitory nearshore processes in a regional repetitive view not previously possible. We see for the first time the structure of large coastal plumes associated with sediment producing areas along the California coast. The four channels of the multispectral scanner show increasing sediment with decreasing MSS channel numbers. In several cases where atmospheric haze is a problem in MSS Channel 4, good sediment patterns are shown in MSS-5. The sediments act as tracer materials and indicate current structures away from the source site. Movement of sediment in the larger estuaries such as San Francisco Bay indicates estuarine flushing patterns. During the examination of the ERTS imagery, it has become evident that during clear weather considerable water penetration is possible. This presents a significant source of information in analyzing sediment transport on the surface and through the water column and associated underwater coastal erosion and deposition. Examples are presented from the Santa Barbara and San Francisco test cells.

2. NEARSHORE PROCESSES STUDY

A number of techniques for analyzing coastal processes from ERTS-A data have been attempted, to date, and the results are included in this report. A combination of photo interpretation methods and computer analysis have resulted in detailed pictures of the surface and subsurface suspended particle structure. The presence of sediment which acts as a tracer for dynamic analysis is a necessity. Patterns in the coastal waters were mapped by densitometer, digital computer and spectral channel comparison. At the present time, a decimal equivalent program is being used to facilitate the analysis of density differences in one or more spectral bands in a given area of interest. The Santa Barbara Channel was used as a test site and the results indicate subtle density changes are readily detectible. These changes analyzed over the area of interest make it possible to map the areal extent and dynamics of the nearshore process structures.

Inspection of ERTS-1 MSS output has confirmed the value of this imagery for synoptic monitoring of various nearshore oceanographic processes. Sharply defined gyres of suspended sediment delineate the boundary between water with evidently quite different characteristics. Aircraft data and groundtruth information is successfully being used to confirm these characteristics visible in the ERTS-A data. The occurrence of such features can be of great importance in designing and interpreting nearshore oceanographic and engineering design programs.

2.1 ENHANCEMENT AND INTERPRETATION

Analyses of the Santa Barbara Channel is described in detail to show the various techniques that were used on the test cell data. This area was chosen because of the favorable weather conditions, several excellent ERTS scenes, sufficient nearshore sediments and the complex current structure present in the channel. Also, computer compatible tape (CCT) data of this area was received early enough to enable detailed computer analysis.

Several techniques have been used for analyzing this test cell including: direct photographic processing (Figure 1), CCT gain change enhancements (Figures 2 and 5), discrete point density analysis and plotting (Figures 3 and 4), and Data Color enhancement (Figures 6-8). It has been possible to not only measure the seaward extent of the suspended sediment but to differentiate and label sediment levels within the sediment lobes. From analyzing the patterns visible on the MSS scenes (mainly Channel 4), it has been possible to determine the surface current structure offshore to a distance, at times, of 45 nautical miles. The analysis of the transitory sediment discharge and the nearshore currents show a clear cut use of ERTS imagery not available by other detection methods.

The Santa Barbara Channel current structure (Figure 1) can be traced by longshore sediments and particulate discharge mainly from the Santa Clara and Ventura Rivers. The relatively cool California current moves into the channel from the west and southwest causing a permanent counter-clockwise eddy in the central channel. A northwest flowing current called the Anacapa current enters the area through the southeastern passage between Anacapa Island and the mainland. This current causes a hydrologic blockage of this southeast passage effectively eliminating the SE movement of locally contributed particulate matter. In the nearshore area between Pt. Conception and Pitas Point net flow is to the east and southeast. This is probably the result of the prevailing westerly winds. Circulation over the Ventura Shelf is dominated by north and northwest flow over the southern portion. Between Ventura and Pitas Point, the northerly flow converges with the southward shelf currents resulting in a wedge of slack water and the turning of current vectors to the west. A second convergence between southward inner shelf currents and the Anacapa current is commonly observed off Oxnard (Drake, 1972).

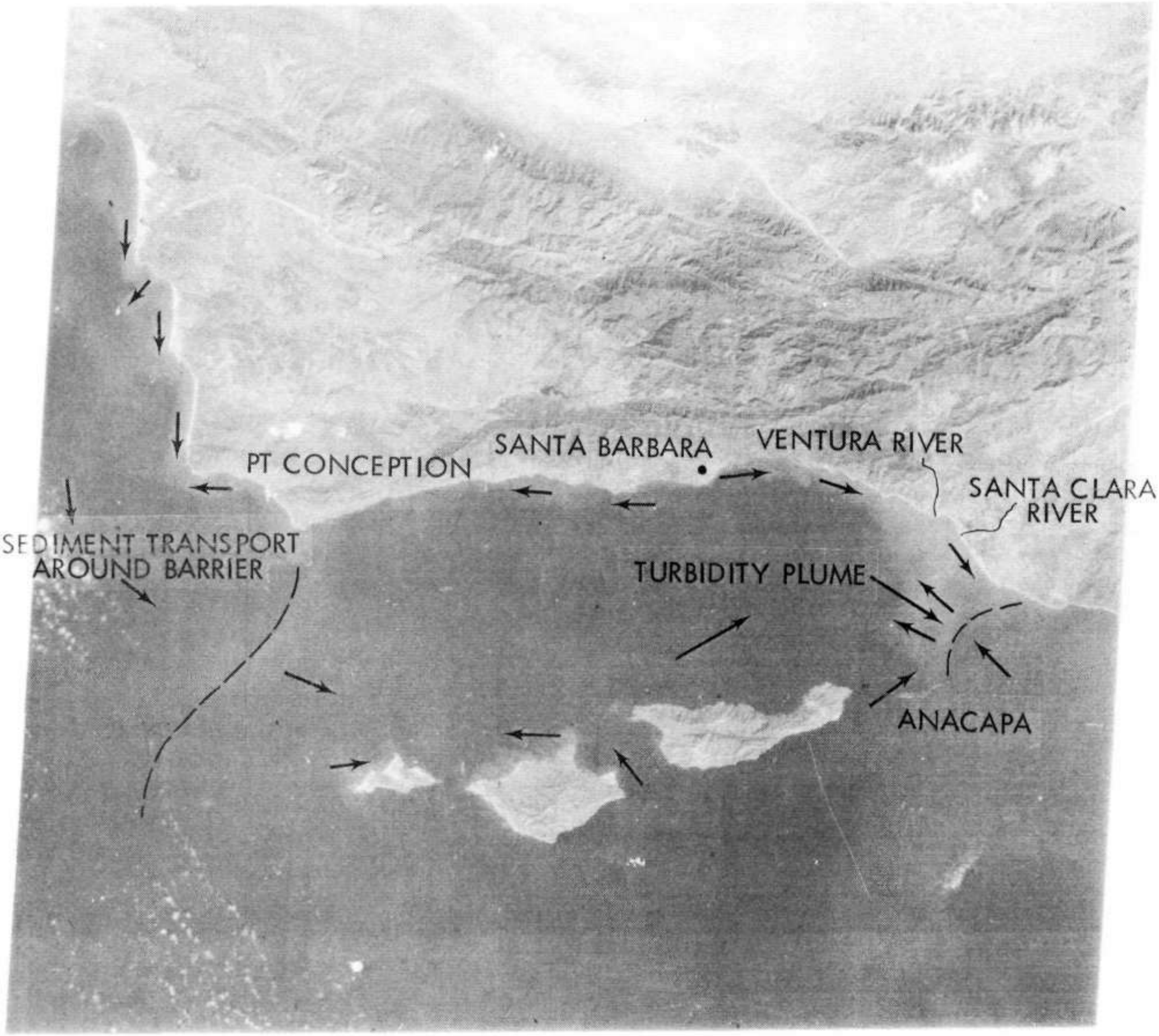


Figure 1 - Santa Barbara Channel 1109-18073-4

The MSS-4 band provides definition of the maximum extent of suspended sediment. Current direction is indicated by arrows. Sediment gyres and eddies around the coastal points and barrier headlands reveal transfer of sediment between the commonly assumed typical California coastal sediment cells with discrete fluvial or mass wasting sources and a down drift sink (submarine canyons). The Anacapa current effect is clearly evident between Anacapa Island and the Santa Clara River moving sediment in the NE direction. Along the coast east of Santa Barbara southeastward moving nearshore sediment transport is visible. A large lobe of material moving seaward from the Santa Clara and Ventura Rivers is also evident. The California current is moving sediment around Pt. Conception into the Santa Barbara Channel in a large concave pattern visible out to 30 miles off the coast. North of Pt. Conception complex nearshore sediment movement is also clearly evident around Purisima Pt. and Pt. Arguello.

2.2 PHOTOGRAPHIC PROCESSING OF ERTS SCENES

The capabilities of the ERTS bands for nearshore processes studies may be summarized as follows. The MSS-4 band (Figure 1) provides definition of the maximum seaward extent of the suspended sediment. Computer analyses of this scene (Figures 2 and 5) is used to enhance the suspended sediment structure within the MSS band 4 and adjacent bands for use in detailed nearshore processes studies. Figures 3 and 4 are graphs of density differences in the nearshore area off Santa Barbara. Figures 3 and 4 also show density changes along two data lines from a NASA computer compatible tape (CCT). The peaks along the graphs represent increases in the offshore suspended sediment content at distances from shore as indicated. These changes in density are created by the combination of pulsing sediment laden river discharge, nearshore currents and wind driven currents. Figure 5 shows the complex offshore suspended sediment structure present off Santa Maria, California.

2.3 DISCRETE POINT DENSITY ANALYSIS

The data presented in Figures 3 and 4 represents a linear conversion of the film image density levels (0.4 to 2.4) to equal increments for use in analyzing the nearshore coastal processes. The density levels are divided by either 0-63 units or 0-127 units, depending on whether bulk or precision CCT's are utilized as source data. The bulk tape has 0 -63 counts while the precision tape has 0 -127 counts (NASA Data Users Handbook).

Experimental runs were made using precision computer compatible tapes of scene 1109-18073-4 and -5. Results obtained indicate an in-water density variation from approximately 19 to 23 counts for spectral band 4 and 15 to 17 counts for spectral band 5 for a total range of 15 to 23 counts. These counts correspond to density level variations from 0.634 to 0.758 (0.0156 per count), a range sufficiently wide to reveal sediment deposit variations as previously described.

Since the precision CCT's are not radiometrically calibrated (reference telecon with P. Heffner, NASA Users Service, March 7, 1973), absolute radiance measurements and comparisons have not been made in any experimental runs to date. Bulk tapes will be used for this purpose in future runs.

While Figures 3 and 4 represent a single N-S line on an ERTS scene, a (see Figure 2) technique has also been developed to provide contour density information for an area. Typically, the Principal Investigator may identify a 6 mile square over which he desires to perform a point-by-point density level analysis. The information is presented to him as a map on which each point is represented by a number corresponding to a density level. The advantage of this technique over conventional photographic reproductions is that it does not depend on the density differentiation ability of the observer to identify varying shades of gray. Instead, the density band is divided into 16 equal steps and a different symbol (hexadecimal notation from 0-F) is used to represent each of these levels. This newly developed method is now being used to analyze specific ERTS scenes that show sediment patterns of interest.

2.4 ISODENSITY PLOTTING

Isodensity plot of MSS channels 4 and 5 in this same area is depicted in Figures 6-8. The isodensity plot of MSS channel 4 due to water penetration properties provides a source for volumetric estimates of the suspended sediment. The less penetrant MSS-5 band gives essentially the two dimensional sediment distribution in the surface waters. Isodensity slicing of the MSS-5 band apparently contours the sediment density changes in the surface water only. Thus, although there is a generalized agreement between the isodensity photos of MSS-4 and MSS-5 bands, they differ in important detail (Figure 6).

Specifically, the MSS-5 band contours better define the longshore drift, and the sediment plume structure in the immediate vicinity of the Ventura and Santa Clara river mouths. Assuming the spectral extinction coefficient for these waters and comparing the difference in the offshore extent of the MSS-4 and MSS-5 isodensity plots, it is possible to estimate the depth of the sediment column represented in the MSS-4 band. Finally, the MSS-7 photographic IR band gives a definition of the extent of nearshore kelp beds which imply the presence of bed rock or large cobbles on the bottom as anchors for the bladder kelp roots.

Sediment gyres and eddies around the coastal points and barrier headlands reveal transfer of sediment between the commonly assumed typical California coastal sediment "cells" with discrete fluvial or mass wasting sources and a down drift sink (submarine canyons, promontory headlands or on-shore dump fields, Figure 1). At the same time, variations in the sediment density reveals the prevailing channel current systems from a synoptic view point.

2.5 SEDIMENT PLUME DEPTH

The water color characteristics are not stable in a given locale, but vary in spectral transmissivity on a seasonal or single storm basis as a direct result of their variable sediment load. Hence, it is necessary to recognize either by an in situ or non-contact technique the prevailing optical properties of the water column throughout the region investigated. This determines the color of the light reaching the sediment and permits the determination of its possible effects on enhancing brightness contrasts between sediment layers due to the motion, position, etc. These contrasts are different in each of the available photographic, spectral band widths. Their magnitude implies the depth limits to which a given spectral brightness contrast can be mapped, since the light becomes progressively deficient in blues and red. Thus, contrasts in brightness in the red or blue between sediment types while mappable at the surface or shallow depths would be unmappable at greater depths. Lacking such sediment color contrasts in turbid coastal waters, the deeper sediment should appear progressively greener with depth.

Further, the light reaching the sediment layer and then re-emerging from the surface suffers attenuation by various mechanisms, which for the deepest depths serve to restrict the image forming light to a very narrow band. To further complicate matters although the dry sediments may show distinct color or brightness contrasts the wetted samples in most cases assume a more uniform gray or brown color.

Mathematically these ideas may be summarized as follows, for the particular wave length band, λ, which characterize the light reaching a given depth, d, the relative contrast, C_λ, d in the photo may be approximately written as:

$$C_\lambda, d = e^{-(\alpha + K \cos\theta)d}$$

where:

- α = the total attenuation coefficient (i.e., $1/\alpha$ is the attenuation length where the light of the particular wave length band has dropped to 1/e of its value when entering the water).
- K = the diffuse attenuation coefficient which is primarily responsible for the change in relative contrast between sediment types as viewed at the surface and at the bottom.
- θ = the slant angle to the object imaged from the photo zenith.

Although there are other significant effects such as surface roughness, which influences reflections and in turn the total light received, the primary factors of concern are the intensity and color of light reaching the sediment layer and the relative contrast of the objects to be imaged. And in fact even the Modulation Transfer Function (MTF) defining the geometrical (size) limits of what can be imaged through a given water column may be neglected, since the method employed is more analogous to optical ranging when the dimensions of the sediment layers (as in this case) are much larger than the poorest size resolution limits anticipated (i.e., a few meters). Based upon this analysis, the initial attempt to establish a spectral control on the planned multiband photographic experiment was to make use of available water transparency data for the Santa Barbara Channel water for this season.

2.6 ERTS-A AND AIRCRAFT DATA

The following figures (Figures 9-14) are interpretations of ERTS-A imagery and simultaneously collected aircraft data. The figure descriptions are self-explanatory but the importance of simultaneously collected aircraft data should be noted. This allows the investigator the opportunity to prove or disprove the features detected on the satellite imagery. Also detailed investigations of surface and subsurface nearshore processes can be analyzed and correlated with seatruth collections. The result is a comprehensive and valuable set of background information for use in the satellite imagery interpretation. This information is not possible without the simultaneously collected aircraft data.

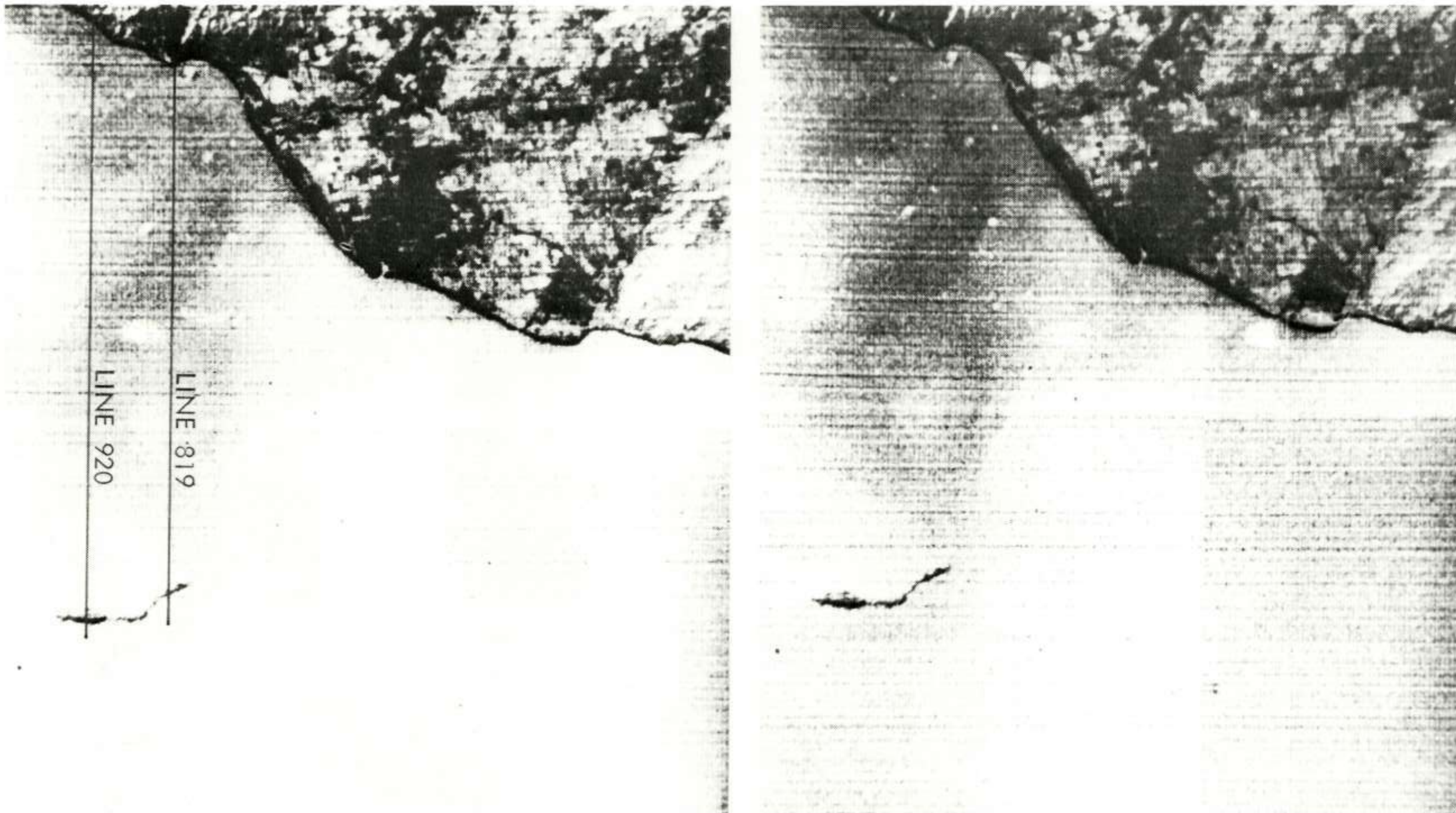


Figure 2. Computer Compatible Tape (CCT) Image of Distribution of Suspended Sediments

The picture covers the southern Ventura Shelf and the eastern portion of the Santa Barbara Channel (scene 1109-18073-4). Port Hueneme, California is visible in the upper center of th picture. Sediment from the Ventura and Santa Clara Rivers is spread across the channel to Anacapa Island. Figure A is an illustration of a film image made from the CCT with signal gain and level set to match the film's density range. The plume of sediment, the primary objective of the enhancement, is faintly visible. Figure B is a logarithmic amplification of the scene. The contrast in the water is increased to emphasize offshore suspended sediment. The land features are overexposed and not as detailed. These are both negative images resulting in the light gray water and dark gray sediments and land.

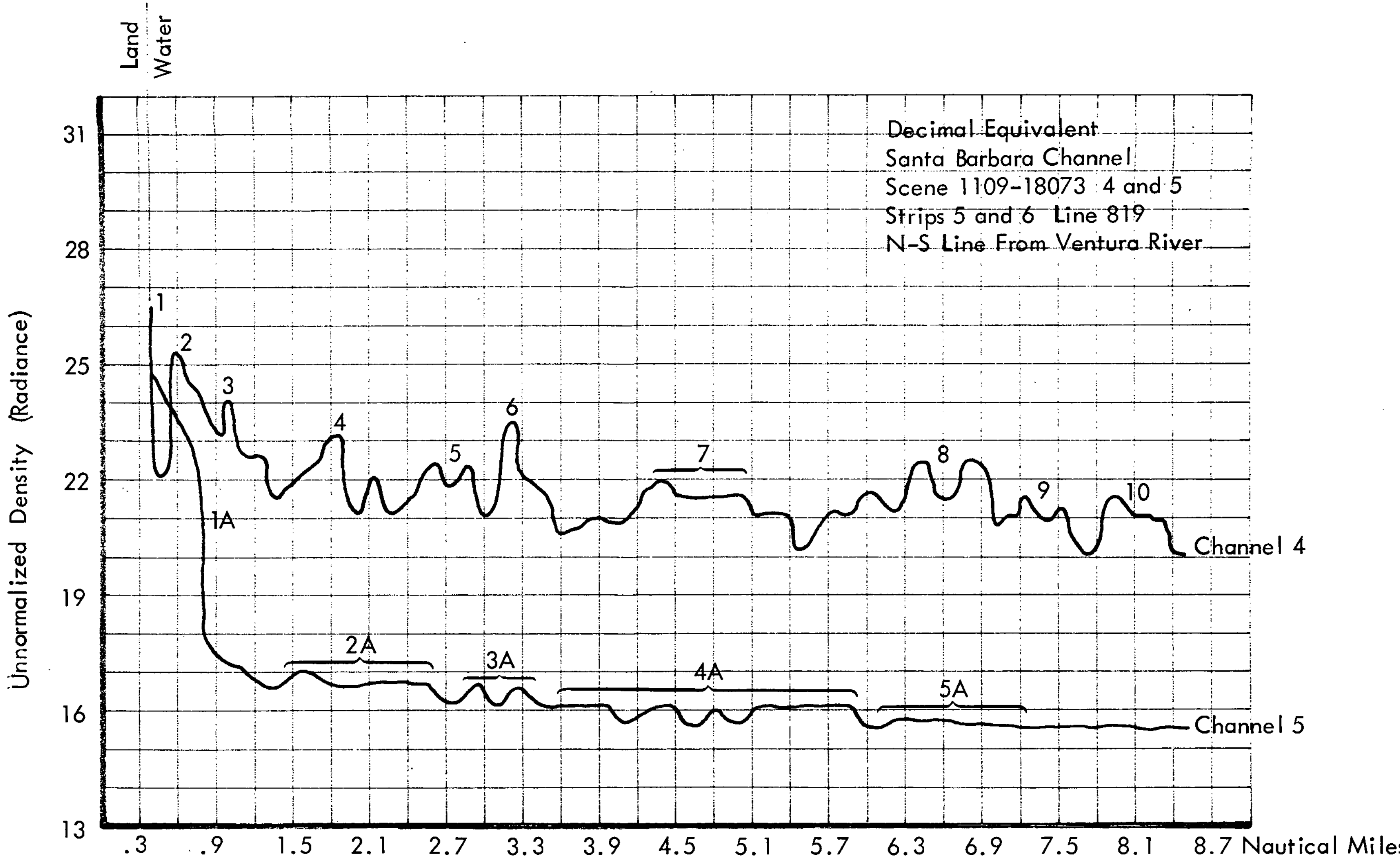


Figure 3. Decimal Equivalent Plot - Santa Barbara Channel

The density differences along line 819 of the ERTS computer compatible tape 1109-18073 4 and 5 are shown to a distance of about 8 miles offshore from the Ventura River (see Figure 2 for location). The upper graph representing Channel 4 contains ten major amplitude changes which can be directly related to increases in density levels related to increase amounts of suspended sediment. The lower graph which represents Channel 5 has five major and minor amplitude changes all of lower density value. The greater water penetration capability of Channel 4 is indicated by the higher density levels and amplitude changes in the Channel 4 graph. This information is used in interpreting nearshore sediment transport. See page 4 for processing description.

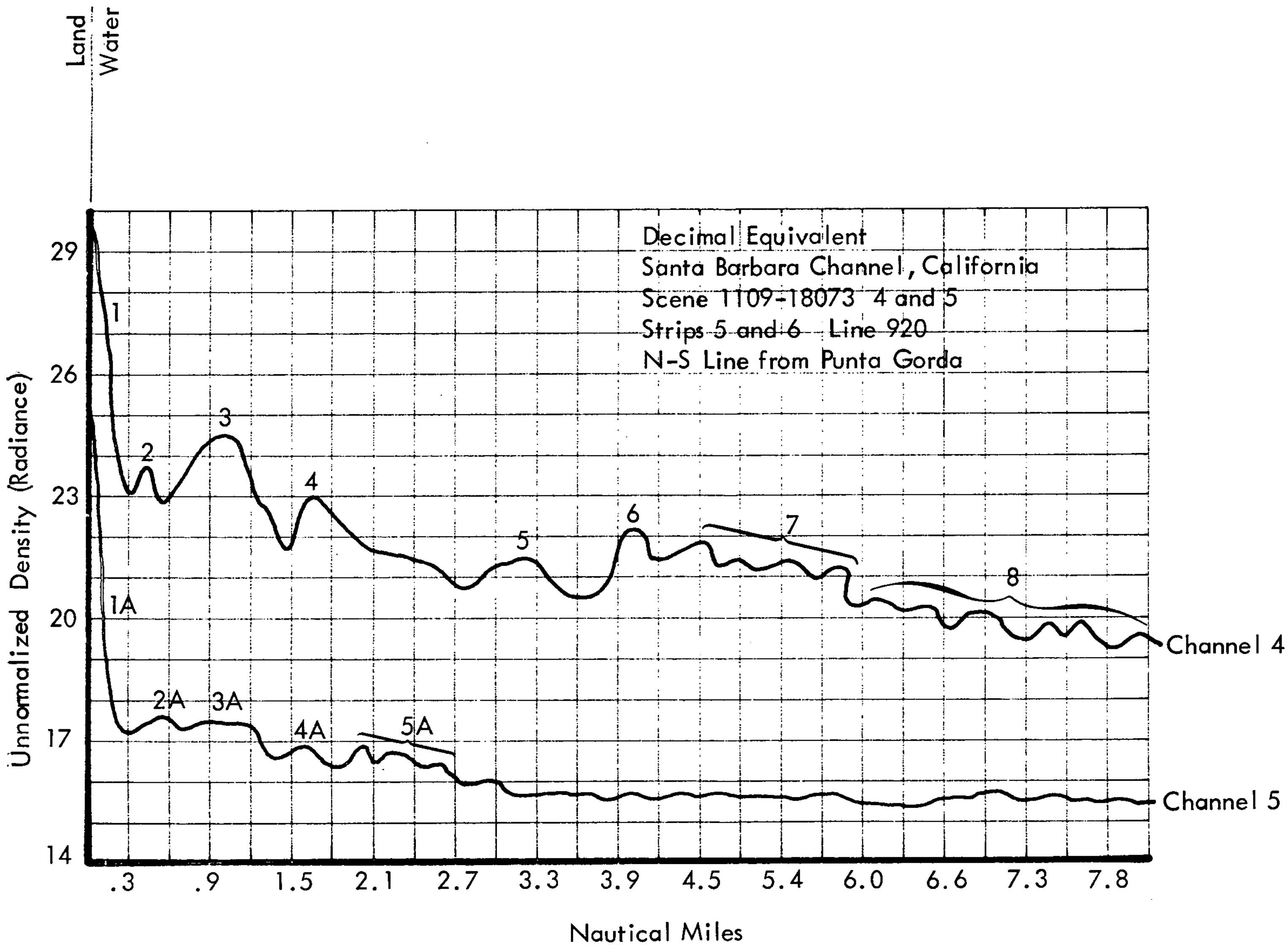
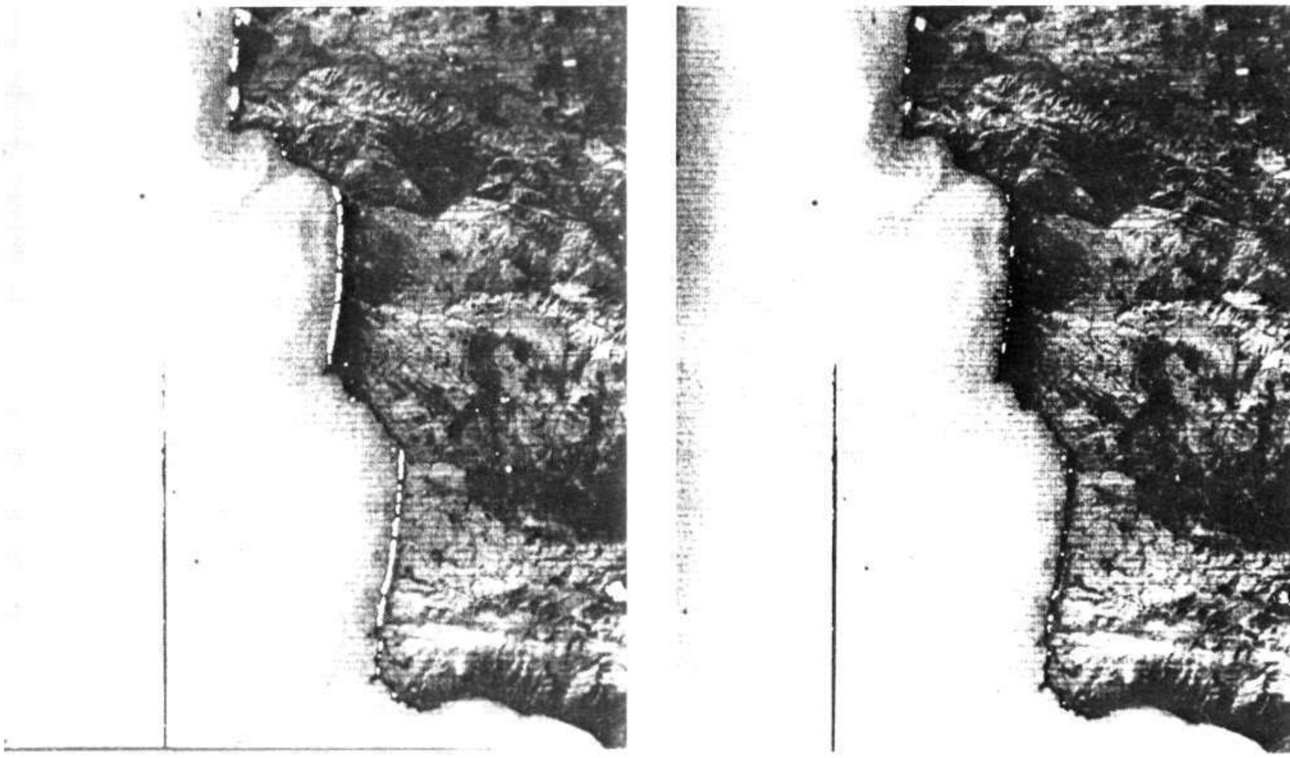


Figure 4. Decimal Equivalent Plot - Santa Barbara Channel

Density differences along this line (920) from ERTS computer compatible tape 1109-18073 4 and 5. This line (see Figure 2) was processed in this same manner as Figure 3 but this line is further away from the major source of suspended sediments (Ventura and Santa Clara Rivers). The overall mean density level for Channel 4 is approximately 21. This is lower than the mean level of approximately 22.5 found for the similar line in Figure 3. These graphs can thus be utilized in areal surface and subsurface suspended sediment analyses.



A B

Figure 5. Santa Maria, California, Coastal Area Scene 1109-18073-4

This is 1/16 of the total scene which has been converted from an ERTS-A computer compatible tape (CCT) to these film images as reformatted on SD's Flying Spot Scanner. The northern point in the picture is Pt. Sal, the center Purisima Point, and the south Pt. Arguello. From Pt. Sal to Pt. Arguello it is 24 miles. Sediment in the nearshore water areas is clearly visible. A large gyre of suspended sediment is circling counter-clockwise around Pt. Sal into the cusp-shaped area south of Pt. Sal before moving southwest offshore. The effects of the California current moving SE into the Santa Barbara Channel off Pt. Arguello are indicated by the tracer sediments.

Figure (A) illustrates a normal contrast image where signal gain and level has been matched to the films density range. Thus, all features within the scene are visible and of nominal contrast. To enhance the contrast of features within the water zone, the land features would have to be saturated or over-exposed. Figure (B) shows a second film image of this scene with increased contrast to emphasize offshore suspended sediment. The land features, however, have not been saturated. This is accomplished with the use of logarithmic amplification.

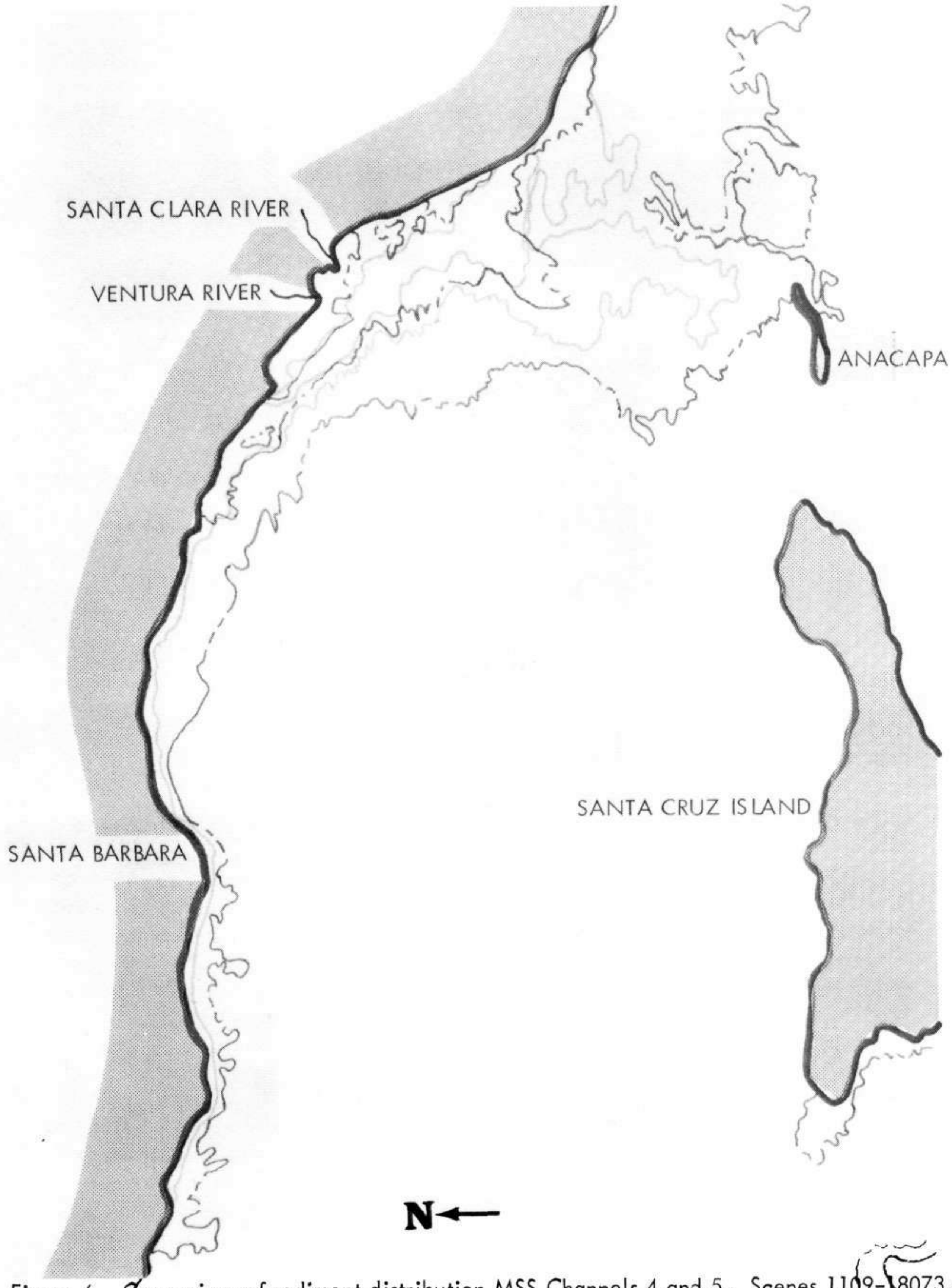


Figure 6. Comparison of sediment distribution MSS Channels 4 and 5. Scenes 1109-18073 of the Santa Barbara Channel area water penetration characterics of channel 4 are depicted. Channel 5 contour represent surface and near surface sediment distribution.

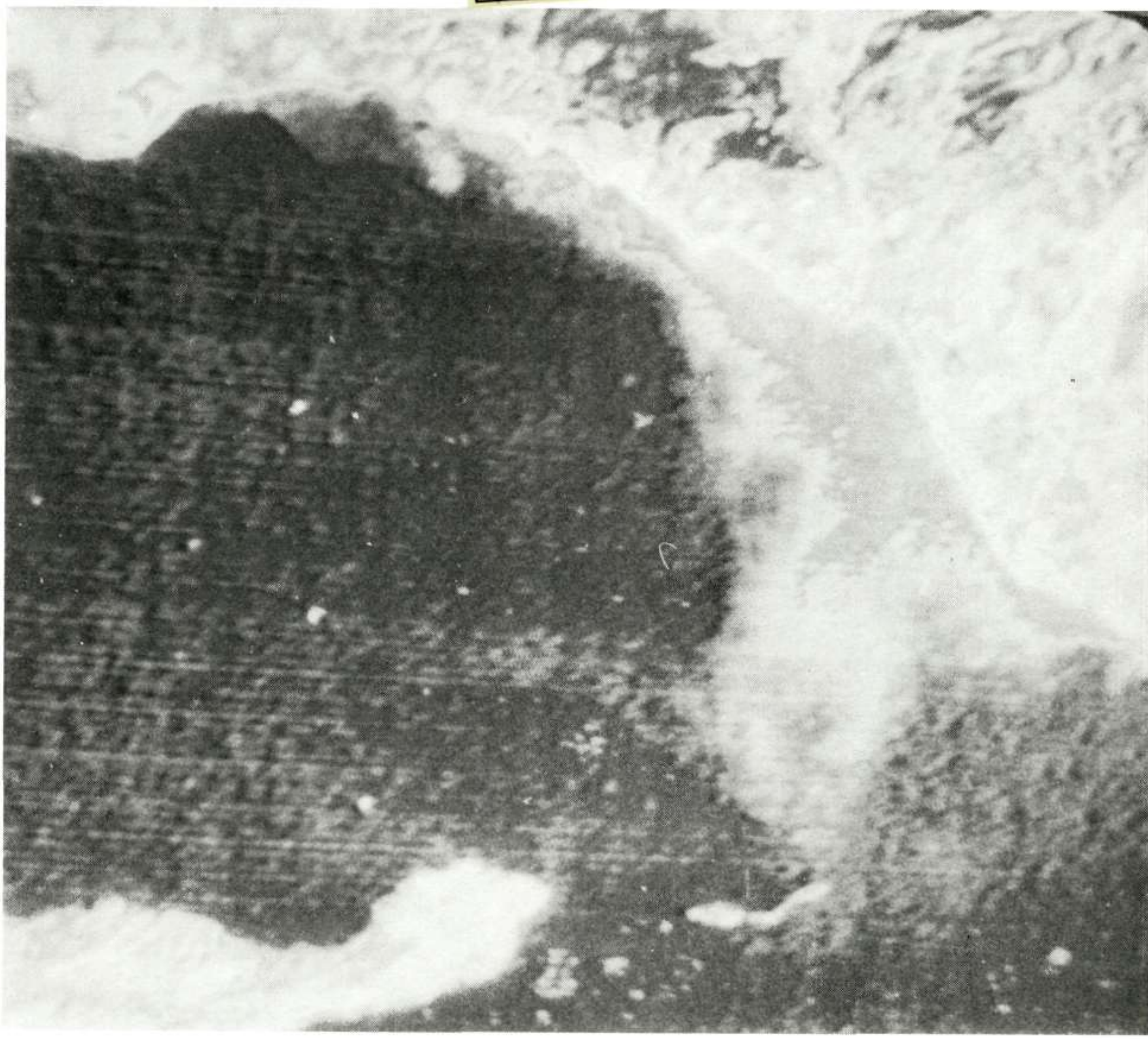


Figure 7. Data Color enhancement of Scene 1109-18073-4 (Figure 1) showing relative concentrations and transport path of suspended material from the Ventura and Santa Clara Rivers. The effect of the southeasterly flowing longshore drift is shown by the area of maximum sediment concentration denoted by a light blue color. The dark blue, light green and dark green areas represent zones of decreasing sediment concentrations in the subsurface water. Entrainment of the sediment plume by the northwesterly flowing Anacapa Current is outlined in dark green. Santa Cruz (lower left) and Anacapa (lower right) Islands are light blue. Orange represents the open ocean waters.

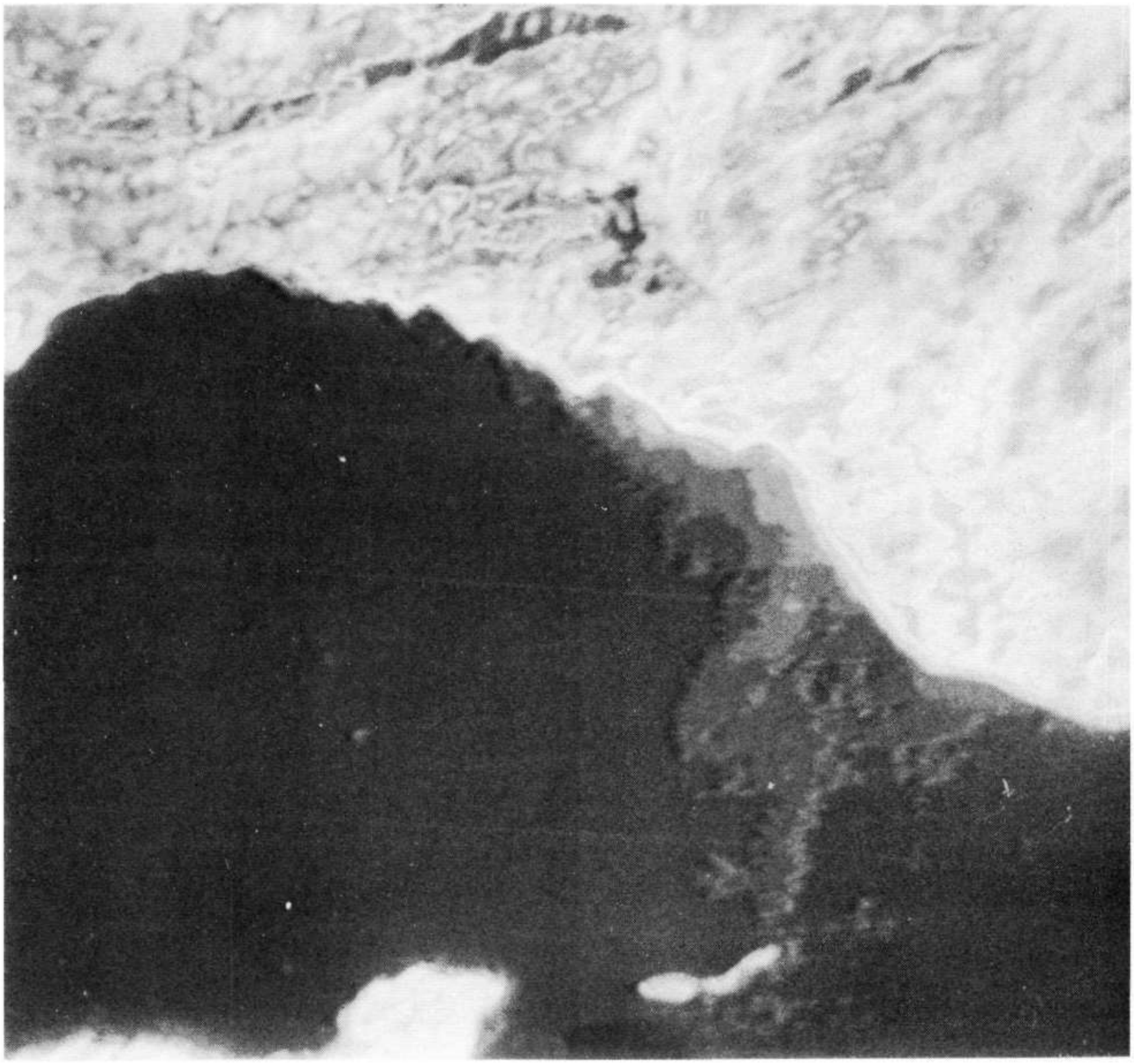


Figure 8. Data Color enhancement of Scene 1109-18073-5 showing the near surface water suspended sediment distribution. The areas of decreasing sediment concentrations are indicated by the light green through dark green colors. The medium green color clearly depicts small scale eddying which is characteristic of this area. Comparison of this enhancement with that shown in Figure 7 represents a means of mapping and differentiating between surface and subsurface sediments.

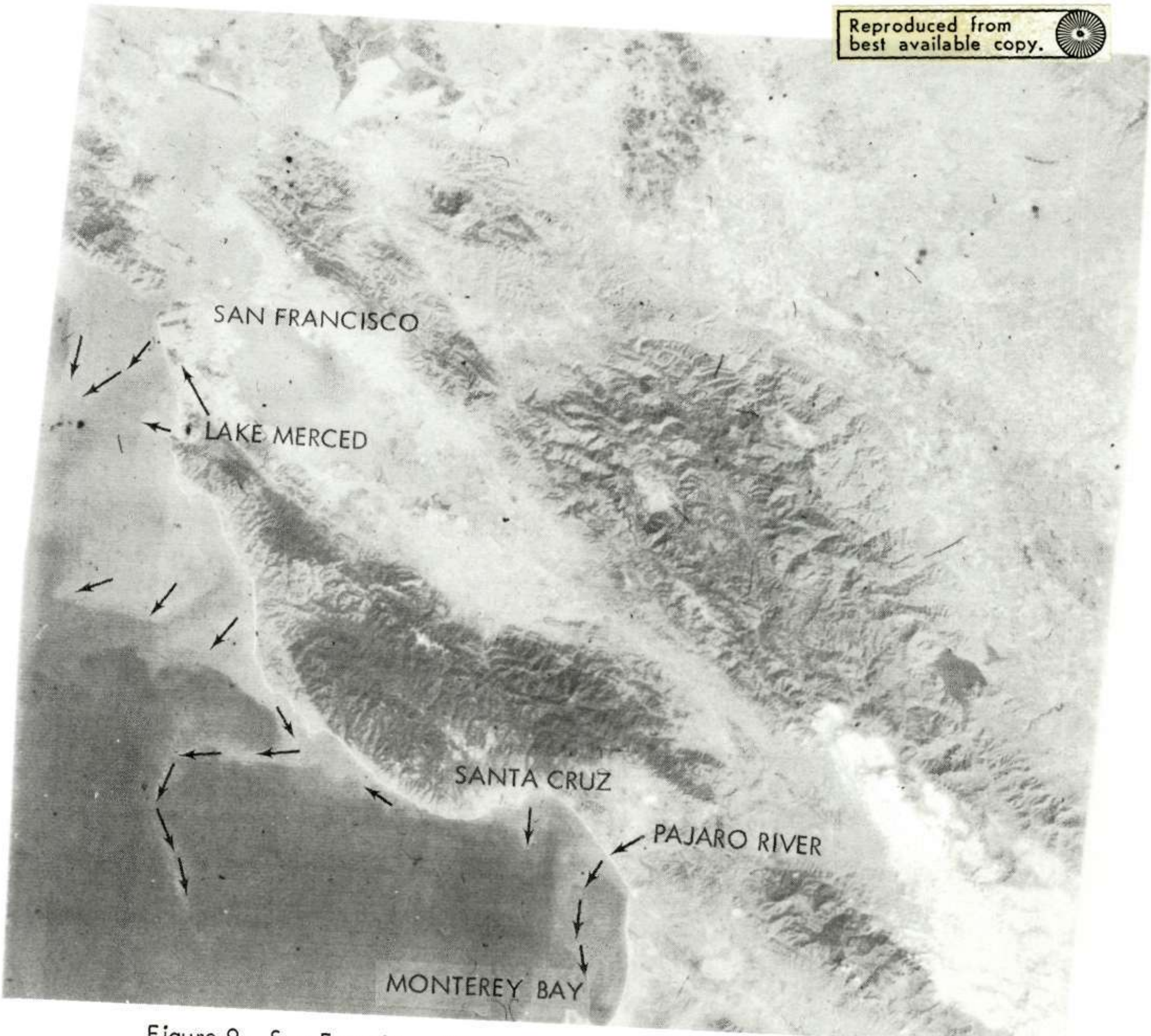


Figure 9. San Francisco-Monterey Bay Area (ERTS 1165-18175-4)

This MSS Channel 4 image was collected on 4 January 1973 at 1017 in the morning. The recent heavy rains during that period resulted in large volumes of sediment being deposited in the San Francisco Bay and coastal areas. Vector arrows indicate the direction of current movement and sediment transport. The California current is moving generally southward at approximately 14.0 nautical miles per day, but numerous gyres and eddies are evident. Off San Francisco just south of Lake Merced a nodal point appears to have been formed. Further south off Pt. Ano Nuevo a large counterclockwise gyre is moving sediment offshore where it is visible out to 30 nautical miles from the coast. In Monterey Bay area sediment from the Pajaro River is being moved offshore and then back onshore near Monterey. There also appears to be a movement of sediment into the Monterey Canyon just south of the Pajaro River in the center of Monterey Bay.

Figure 10. Southern Monterey Bay - Water penetration in Monterey Bay which clearly shows current pattern, sewage outfall patterns, wave trains and kelp beds. This aircraft photograph was taken at the time of the red tide and shows areas of concentration. The area of dark gray sediment (circle) nearshore is a result of a sand mining operation. The use of a yellow Wratten 12 filter with Ektachrome color film was found to give excellent water penetration for the analyses of current and sediment patterns.

Figure 11. Bolinas Bay - Movement and deposition of sediment at the entrance to Bolinas Bay is clearly visible in this aerial photography. A bar in the shape of a triangle has been deposited at the entrance adjacent to Stinson Beach. Erosion at the base of the cliff to the left of this entrance is continually taking place endangering the adjacent property. Longshore currents are moving suspended sediment generally to the south (bottom) and the east (right).

Figure 12. (Top) Southern California - ERTS (1144-18015-4) This MSS channel 4 image of Southern California was taken on 14 December 1972 at 1001. There was not a great amount of suspended sediment in the water at the time of this image but it is shown to illustrate the useful ERTS imagery resolution in detecting small amounts of sediment discharge. Simultaneous with the ERTS satellite overflight, the bottom picture was taken from an aircraft with Ektachrome film and a Wratten 12 filter. The sediment plume issuing from Newport Harbor (in circle) is readily visible on the ERTS imagery. The breakwaters are 800 feet apart at the ocean entrance to Newport Harbor. The plume itself is 1600 feet wide at a distance of 1600 feet from the end of the breakwaters. The counter-clockwise movement of this plume moving back toward the coast is visible on the ERTS image. In the simultaneously collected aircraft photography layering within the sediment discharge can be detected in detail. A small boat is visible leaving Newport Bay at the Harbor entrance. Offshore "Santa Ana" winds were blowing all day, 13 December, and into the 14 December when this ERTS imagery was collected. The offshore patterns indicated by the wind vector arrows resulted from wind blown sediment. This sediment was transported down the coastal canyons and out to sea where it is visible at a distance of up to 25 nautical miles. These patterns vary in bearing from almost N-S near Pt. Dume to NE-SW off Palos Verdes and Newport Bay.

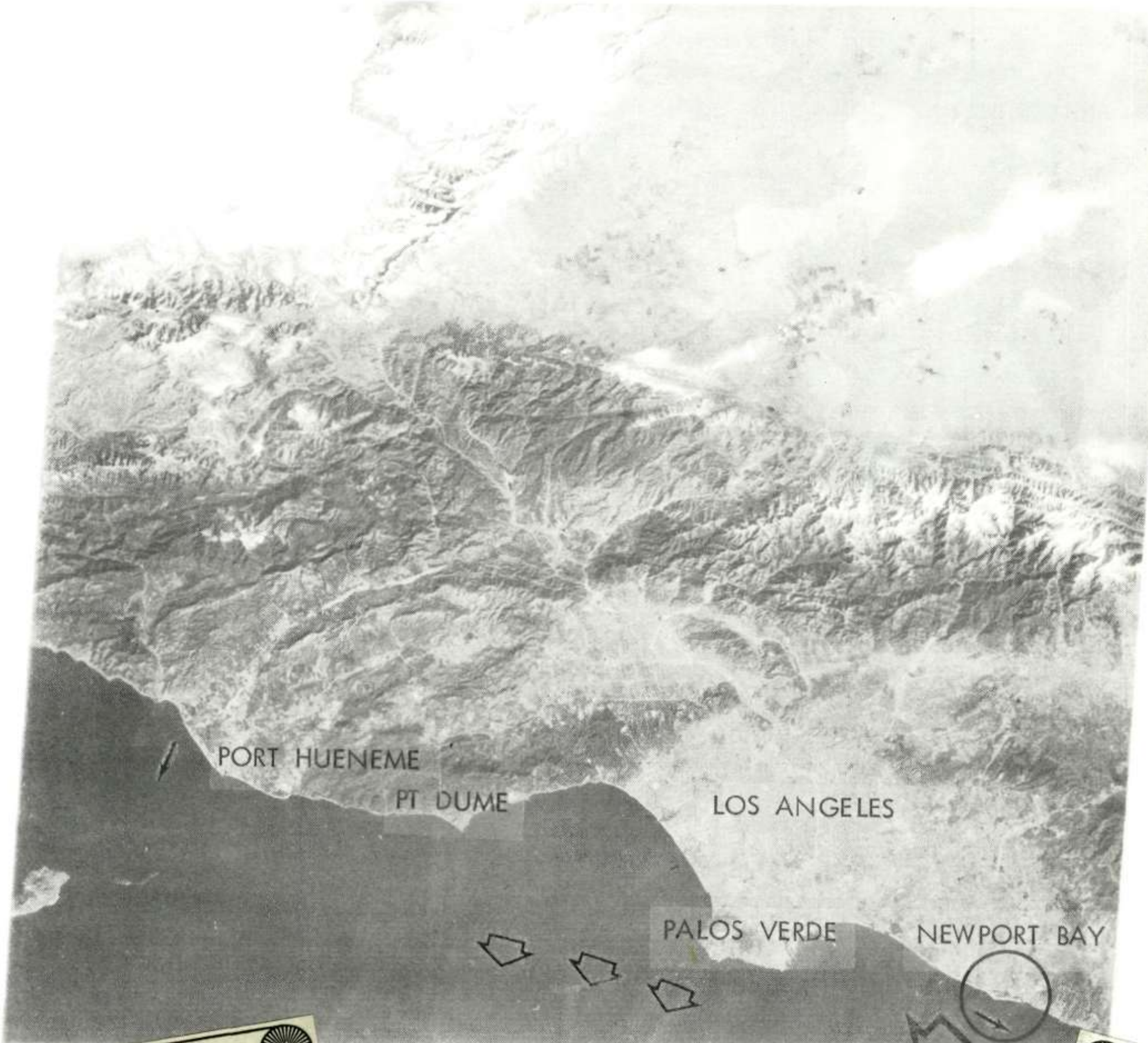

PORT HUENEME
PT DUME
LOS ANGELES
PALOS VERDE
NEWPORT BAY

FIGURE 12


WIND VECTORS
CURRENT VECTORS

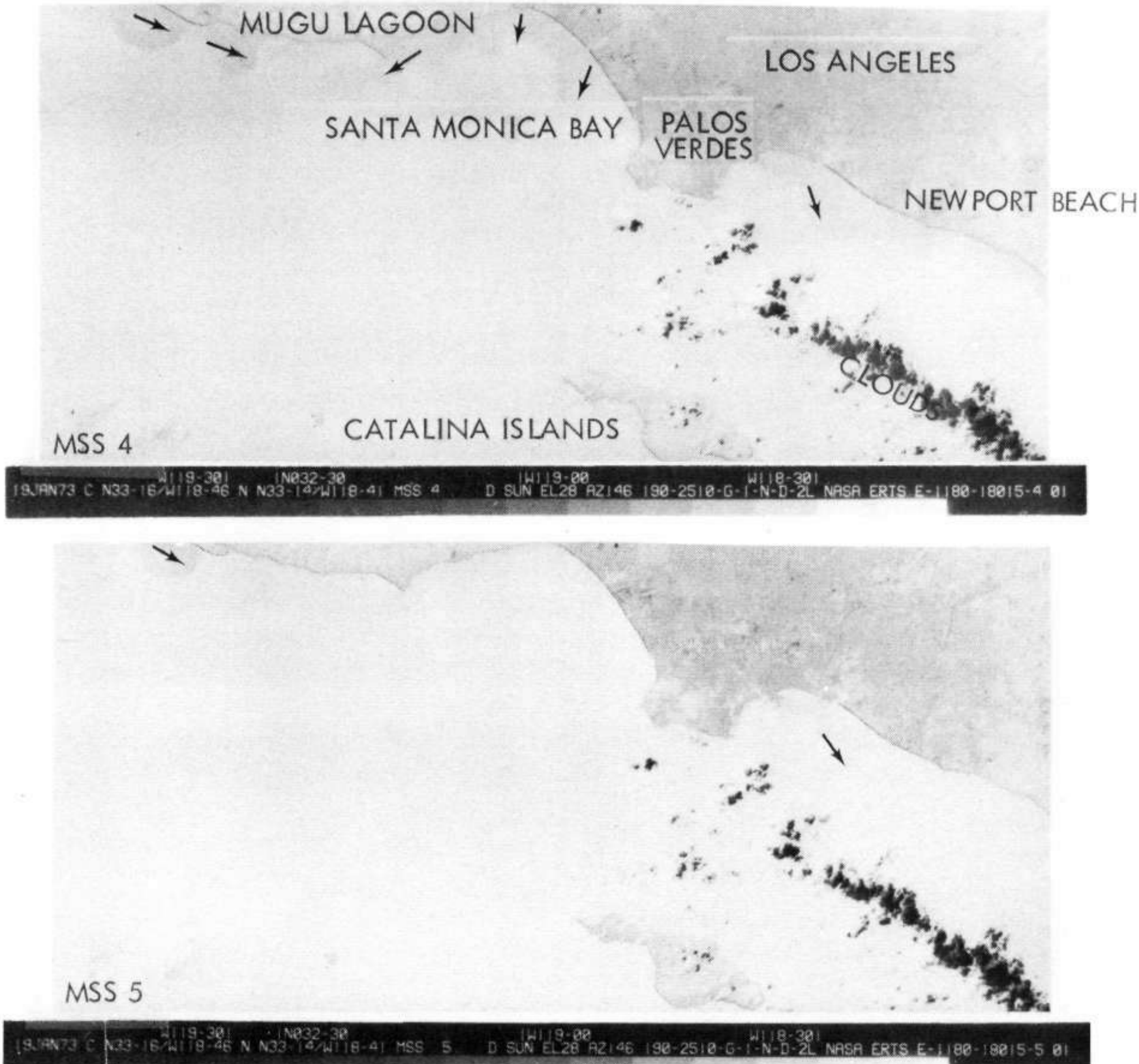


Figure 13. Mugu Lagoon to Newport Beach (ERTS 1180-18015)

These are prints made from positive transparencies which result in a density reversal -- blacks are white and whites are black similar to a negative. This was done to enhance the suspended sediments in the nearshore area. The top picture is MSS Channel 4 and the bottom picture is MSS Channel 5. Note the greater water penetration in Channel 4 becomes obvious in this comparison. Sediment moving offshore by current action as indicated by the arrows can be clearly seen. This set of imagery collected on 19 January 1973 came after an extended period of rains. The transitory effect of fluvial sediment runoff carried to the ocean and transported by the nearshore currents is observable in a regional manner. In the area of Mugu Lagoon the discharge from the Santa Clara/ Ventura Rivers (upper left) and the lagoon is being moved southeast. In Santa Monica Bay a southwest counterclockwise current is affecting sediment off Pt. Dume. The Los Angeles, San Gabriel and Santa Ana Rivers east of Palos Verdes and west of Newport Beach are all adding suspended material to the downcoast sediment transport budget.

In the MSS Channel 5 picture at the bottom of this figure the surface definition of the suspended sediments are shown. This channel defines the longshore drift and the sediment plume structure in the immediate vicinity of the river discharge areas. The abrupt movement of suspended sediment around the end of the San Pedro Bay breakwaters is obvious in this channel.

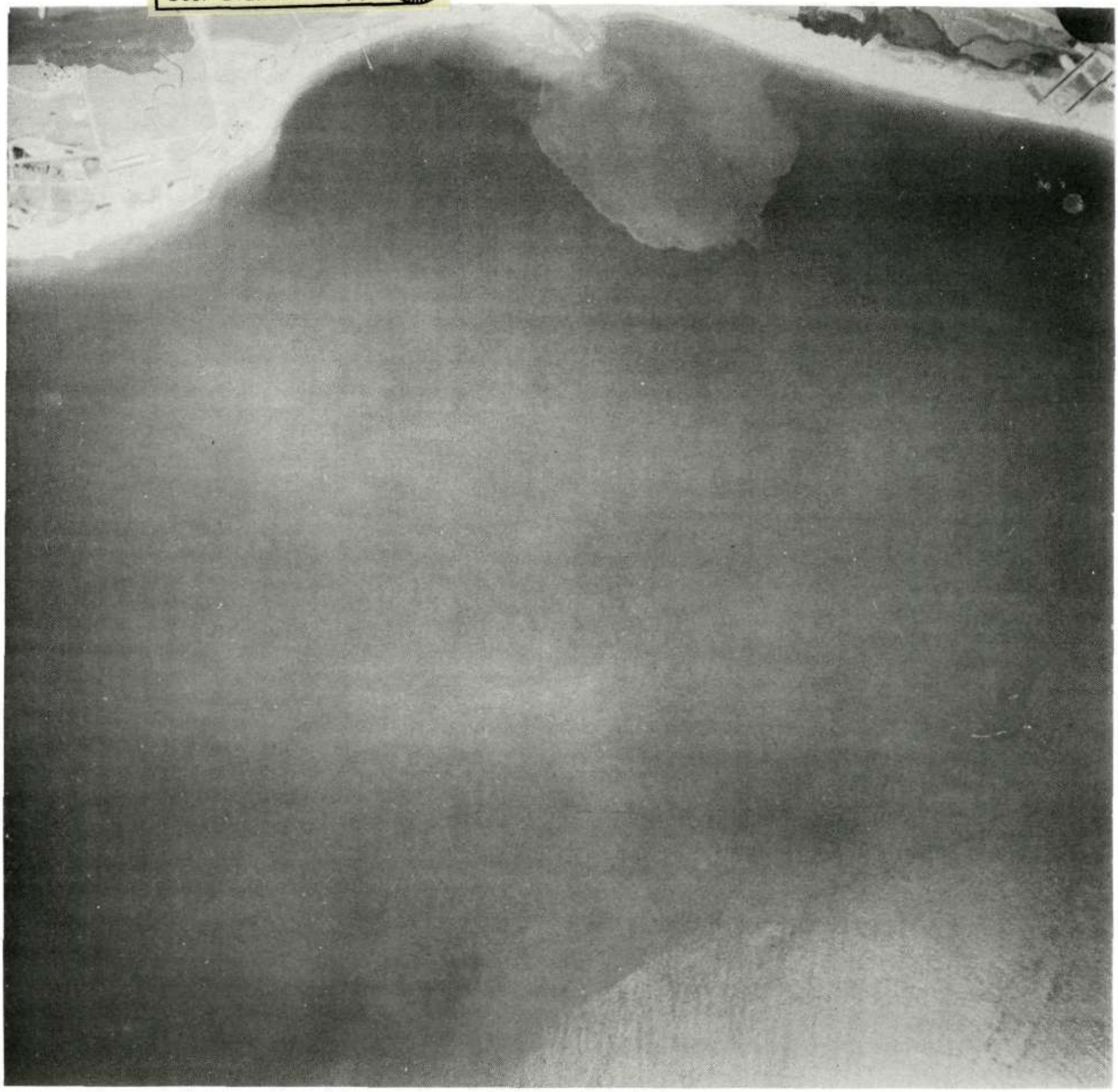


Figure 14. Mugu Lagoon Area

The aircraft photograph of the Mugu sediment discharge shows one of the many areas illustrated in Figure 13. Sediment within the lagoon is moving out through the lagoon entrance and is being dispersed generally to the southeast (right) by wave and current action. The two heads of Mugu submarine canyon are just off the pier to the west (left) of the sediment plume. An obvious break in the downcoast movement of suspended particles from the left is visible at the canyon boundary indicating down canyon deposition. Pirie's (1972) measurements with a PRT-5 radiometer in the area indicate temperature difference over the two canyon heads which are often present. The differing density of the sediment lobes issuing from Mugu Lagoon appear to be resulting from a combination of the canyon head temperature differential and currents and the longshore drift in the area. This picture was taken on Ektachrome film with a Wratten 12 filter which was used for maximum suspended detection. The film was exposed at 1 1/2 stops above normal in order to obtain maximum water penetration.

2.7 EMSIDE SCANNER DATA

Emside Scanner Imagery taken simultaneously with an ERTS-A overflight on December 14, 1972 shows details of three nearshore features within the Los Angeles area test cell (Figures 15 to 17). The Emside system is a 9-channel image-forming scanning spectrometer. Spectral reflected energy is collected from ground features, processed, and recorded onto 9 parallel analog tape channels for post flight processing and film recording. The recorder analog video signals are calibrated in absolute reflectance levels for future analysis. The following table illustrates scanner's technical details:

Channel (Numbers)	Spectral Band (microns)	Detector
1	.4054 - .4297	S-20 PM
2	.4461 - .4880	S-20 PM
3	.4907 - .5530	S-20 PM
4	.5500 - .6100	S-20 PM
5	.6160 - .6650	S-20 PM
6	.6700 - .7100	S-20 PM
7	.7250 - .8200	S-1 PM
8	.8600 - .9600	S-1 PM
9	1.000 -1.100	Photo Diode

Scanning Rate	100 revolutions/sec
Instantaneous Field of View	2.5 milliradians
Later Scan Angle	120°
Spectral Reflectance Accuracy	1.0%
Analog Tape Recorder	Sangamo Sabre III

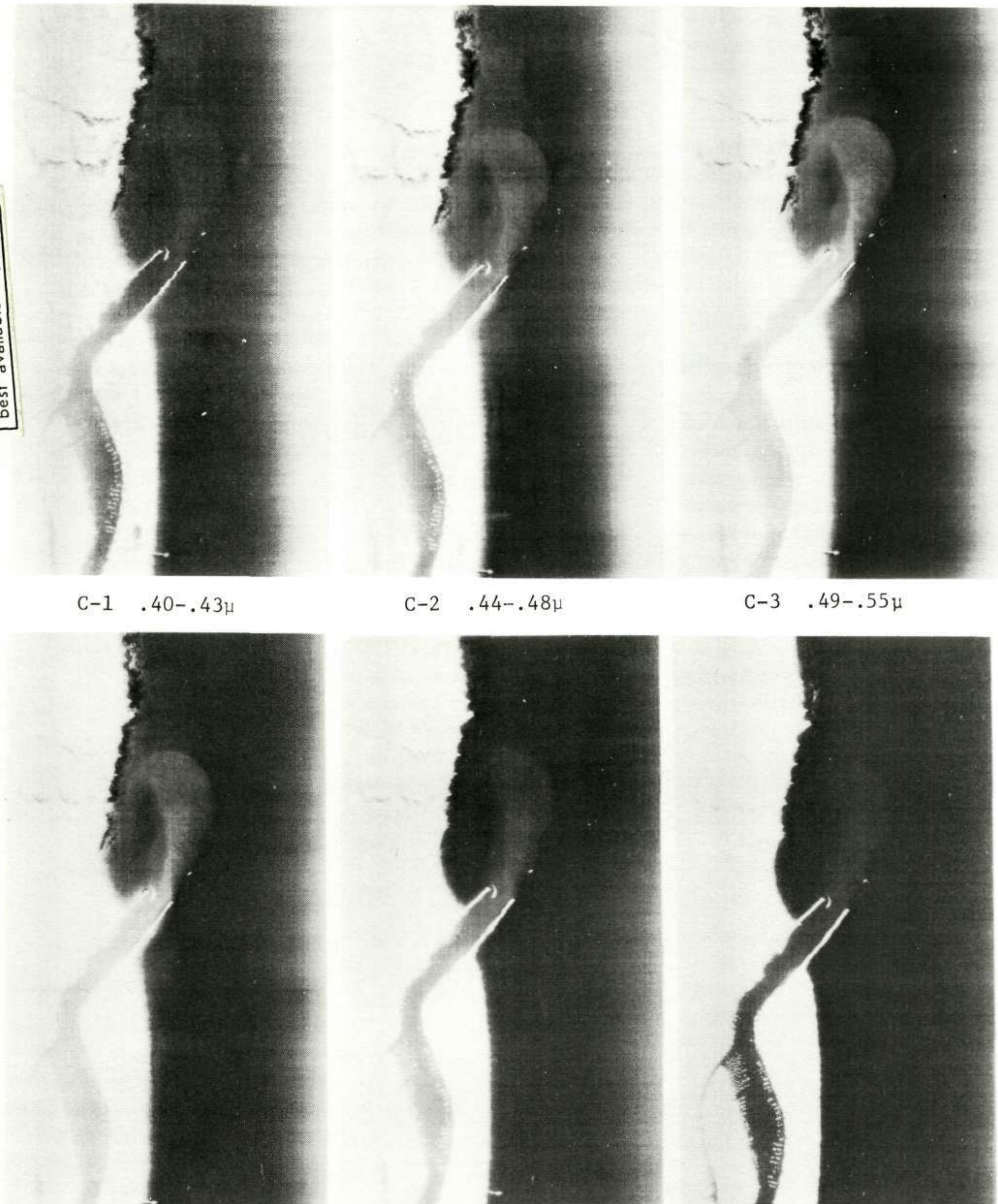
Post flight processing of the Emside data collected over the Los Angeles test cell was performed in two phases. During Phase I, all data collected with the system was recorded onto film using appropriate gains so that no feature saturated, that is the signal dynamic range or reflectance range was matched to the film's density range. This resulted in a complete set of nine multispectral scenes of each flight line. Features of interest such as sediment plumes, surface outflows, and other anomalies were pinpointed and isolated for further processing. The three targets selected are shown in Figures 15 through 17. Figure 15 illustrates a sediment plume in the vicinity of the entrance to Newport Harbor, Figures 16A and Bshows an anomaly within Los Angeles Harbor in the area of Fish Harbor, and Figure 17 portrays the surface outfall off White's Point sewer. The multispectral scenes shown in the above figures are imagery processed during Phase II.

C

Once the areas of interest were defined and isolated, the data was reprocessed through a wide bandwidth high gain linear amplifier to display maximum contrast of the features of interest. These high contrast films allow the interpreter to progress from simply location features, as is possible from Phase I imagery, to an analysis of the processes surrounding and affecting these features. One may also point out that from the Phase I results the interpreter was able to perform a type of filtering process while reviewing his total data set. That is, only areas of specific interest were selected for further processing. This is important since Phase II type processing is more time-consuming than Phase I.

As is evidenced from reviewing the selected features, the anomalies display spectral signatures. In the case of the suspended sediment issuing from Newport Harbor (Figure 15) the anomaly is shown best in Emside channel No. 4. Its signature, however, is still present in channels 2 and 3. This correlated with ERTS channel MSS-4. Thus, one would expect to be able to detect this type of sediment in only one ERTS data channel. The spectral signatures of the anomalies near Fish Harbor (Figure 16), however, extends from Emside channel 2 through channel 6. These spectral signatures are broader than the first and cover ERTS MSS channels 4 and 5 signatures. Thus, a distinction can be made between the two features. The third feature, the sewage outfall off White's Point, shows response in Emside channels 1 through 6. The peak reflectance in this example is in channel 4.

Steller, et al, (1972) described the use of edge enhancement processing of similar Emside data to further define the differences in densities present in Emside imagery. This technique in effect contours the density (suspended sediment) levels. It is, thus, possible to use edge enhancement to define the areal extent of material detected in Emside imagery.

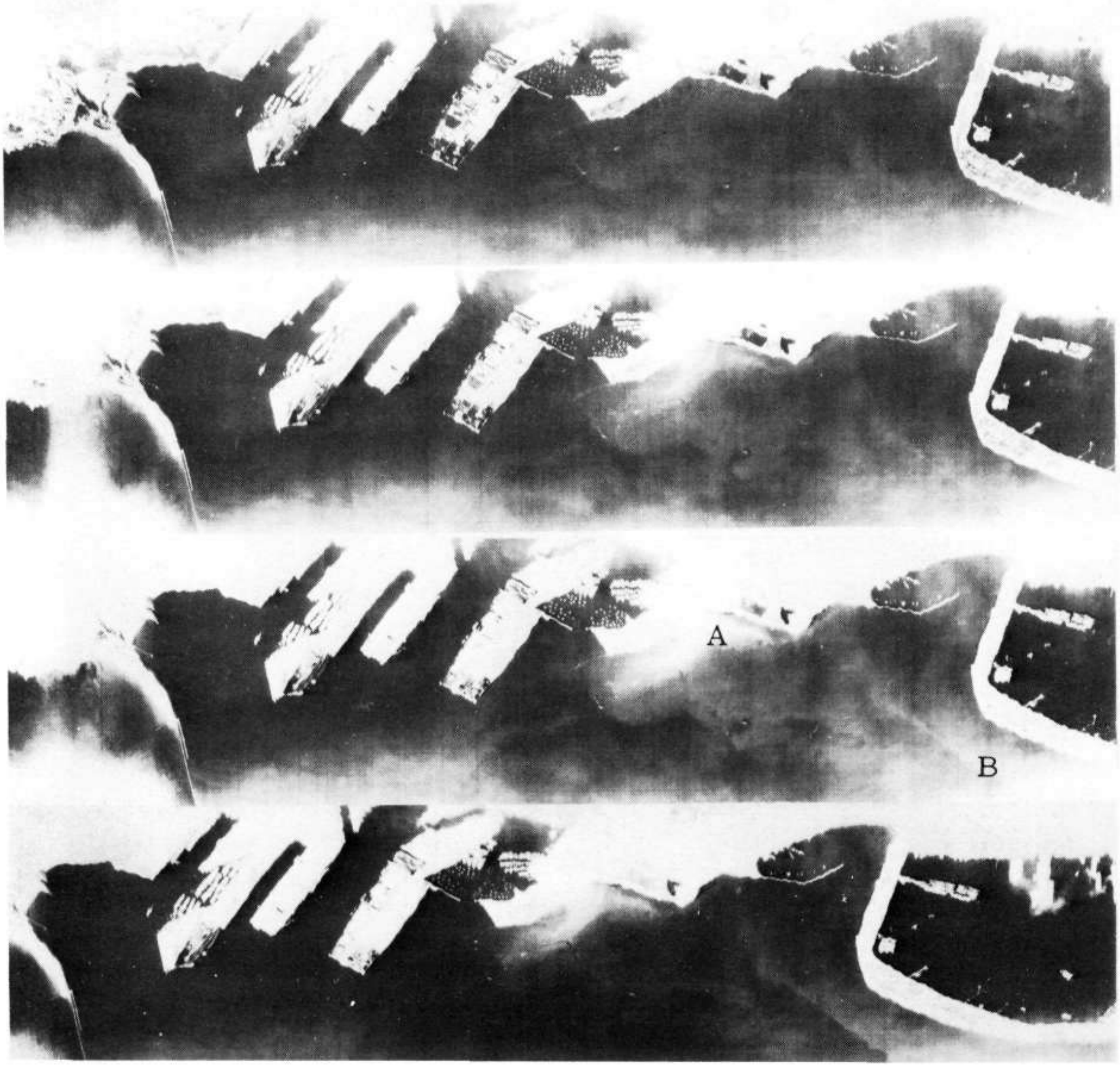


C-1 .40-.43μ C-2 .44-.48μ C-3 .49-.55μ

C-4 .55-.61μ C-5 .61-.66μ C-6 .67-.71μ

Figure 15. Newport Harbor - December 1972

Emside scanner data shows the sediment transport at the entrance to Newport Harbor. This sediment plume was detected by the ERTS satellite (Figure 12) which was passing this area simultaneously with this aircraft-collected Emside data.



C-1 .40-.43μ

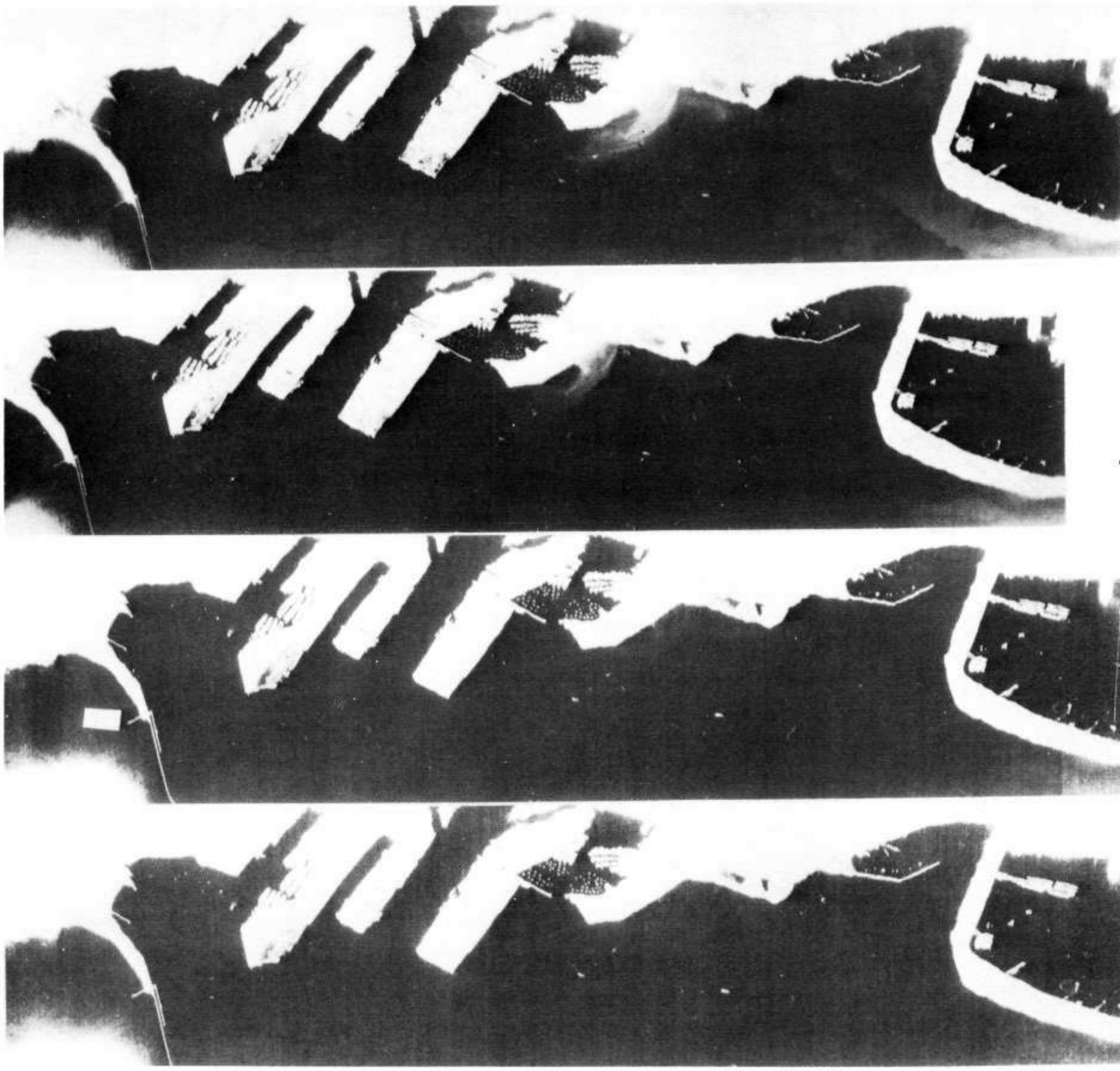
C-2 .44-.48μ

C-3 .49-.55μ

C-4 .55-.61μ

Figure 16 A and B. Los Angeles Harbor Emside

Emside scanner imagery collected on 14 December 1972 simultaneously with ERTS data (Figure 12). The outfalls containing fish oil waste and sewage are located at Point A, channel (C-3). The material being deposited into the harbor at that point is being carried to the southwest (left) by surface currents in the harbor area. The sharp reflectance difference between channels 1 and 2 presents a means of differentiating these pollutants which act as tracers in studying currents. Peak reflectance is in C-3 with an obvious drop off through C-6. By C-7 absorbtion is complete for these materials. At Point B-a linear disturbance in surface pollutants is present. It was probably caused by the mixing effect of a passing boat which combined the clearer subsurface water with the surface water.



C-5
.61-.66μ

C-6
.67-.71μ

C-7
.72-.82μ

C-8
.86-.96μ

Figure 16 B

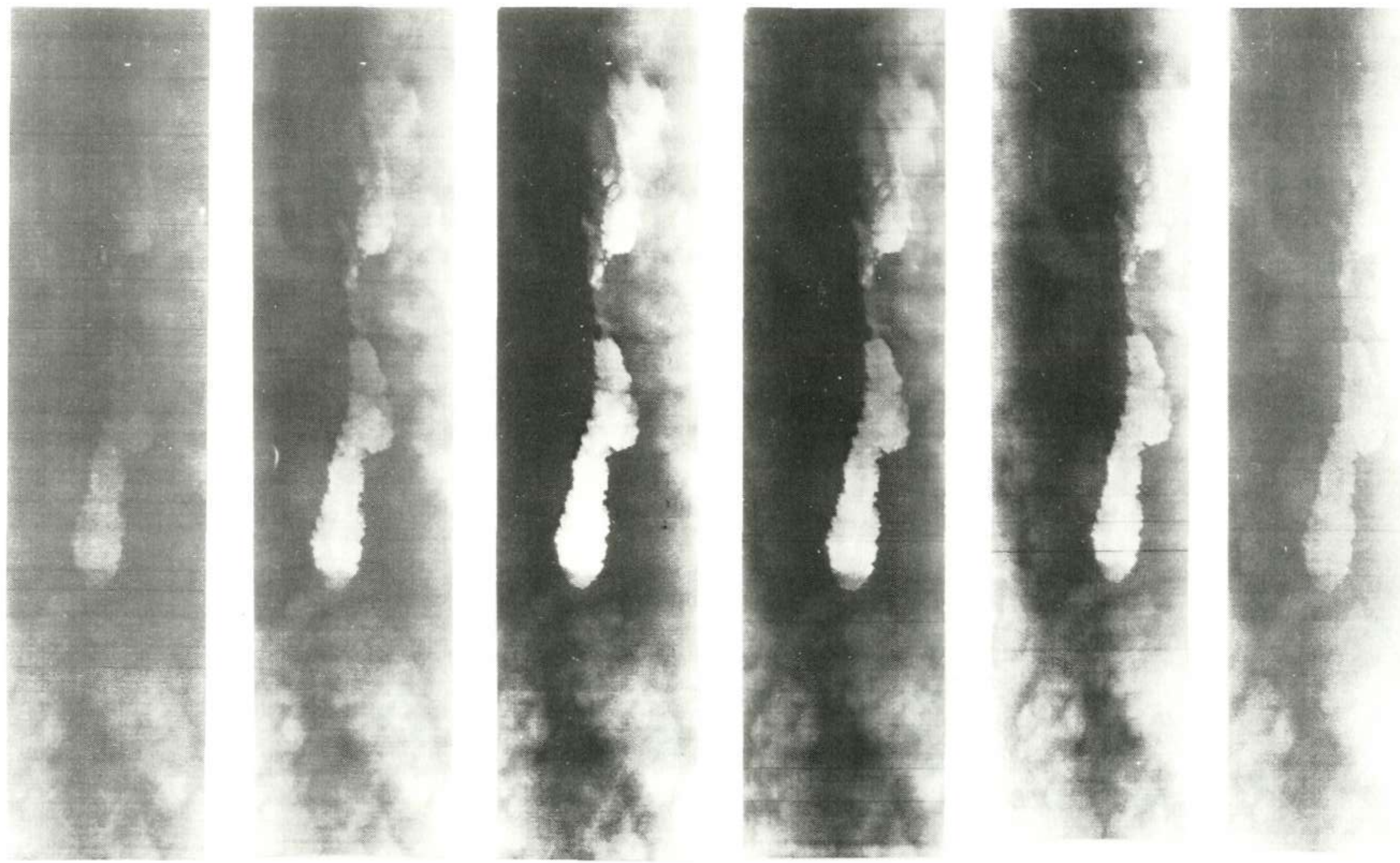


Figure 17. White's Point Sewage Outfall, Palos Verdes Peninsula, California

These Emside video images were taken on December 14, 1972 simultaneously with the ERTS overpass. The surface current was moving these suspensates to the west (left) and dispersing them along the Palos Verdes Peninsula. Emside channels 1-6 show the variations in spectral reflectance with the peak reflectance measured in channel 4.

3. PROGRAMS FOR NEXT REPORTING PERIOD

The next reporting period which ends April 30 will be used primarily for conducting the additional aircraft flights and ground truth collection in the San Francisco-Monterey Bay area. During the January-February 1973 period three flights in that area were cancelled because of poor weather. These flights are re-scheduled for the next reporting period plus an additional flight in the Santa Barbara Test Cell.

The discrete point density analysis will be utilized with bulk CCT data expected to arrive soon. This will allow for automatic contouring of density levels on computer printouts for correlation with sea truth and aircraft data. Analysis and interpretation of ERTS film and computer compatible tapes will continue.

4. CONCLUSIONS

Transitory nearshore processes can be detected, delineated and monitored by analyzing ERTS data combined with simultaneously collected aircraft and seatruth information. This is especially true of sediment transport, river discharge characteristics and nearshore currents.

Analysis of the ERTS computer compatible tapes has been used to measure scene reflectance line by line. This information has been related to sediment content detectable in MSS channels 4 and 5. Subtle sediment lobe characteristics result, allowing the investigator information not available by photographic techniques. This technique is being expanded to automatically contour scene density levels in the nearshore zone of interest.

Densitometer line and scene traces of ERTS imagery have been successfully used to: delineate surface and subsurface sediment distribution, differentiate nearshore morphologic units, map current effects and compare MSS channel signals.

Emside scanner video information has been processed to detail sources of nearshore particulate matter. This information collected by aircraft was then used in interpreting the ERTS imagery. Detailed spectral signal analysis of the trace material thus becomes possible.

The use of Ektachrome film with a Wratten 12 filter has proved most successful in the aircraft recording of nearshore processes. Use of f stops open 1-1/2 to 2 stops beyond normal exposure resulted in the most useful information.

5. RECOMMENDATIONS

None

6. INDEX

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SIGNIFICANT RESULTS

California Coast Nearshore Processes Study Contract S-70257-AG

Douglas M. Pirie, DE324 — Principal Investigator
David D. Steller — Co-Investigator

Progress Report Type II, No. I — September 1, 1972 - February 28, 1973

Report Category 5H

1. By utilizing special photographic processing techniques on ERTS imagery appearing to contain little suspended sediment (i.e. printing to enhance subtle density differences in nearshore water and the use of negative prints), it is possible to enhance minor traces of sediment in coastal waters. Interpretation of nearshore processes using these sediments as tracers then become possible. In cases where aircraft remote sensor data or sea truth is available it is possible to confirm the interpretation. This was demonstrated in the fall 1972 ERTS imagery of the Los Angeles test cell during a period of little rain and low sediment runoff.

2. Analysis of the ERTS computer compatible tapes was used to measure scene radiance line by line. This information was related to suspended sediment content detectable in MSS channels 4 and 5 for the Santa Barbara Channel between Ventura and Anacapa Island. Subtle sediment lobe characteristics result supplying the investigator with information not available by photographic processing techniques.

3. Densitometer measurements (isodensity and line traces) of the ERTS imagery were successfully used to delineate surface and subsurface sediment distributions (Santa Barbara Channel), differentiate nearshore morphologic units (San Francisco Bay) map current effects, and compare MSS channel signals.

4. Emside nine channel scanner video information was processed to detail sources of nearshore particulate matter at Los Angeles Harbor, Newport Bay and White's Point. The Emside information collected by aircraft simultaneously with the ERTS overpass, was then utilized in interpreting the ERTS data. Detailed spectral signal analysis of the trace particulate material in the coastal waters thus became possible.